ASPECTS OF REPRODUCTION, SETTLING AND GROWTH IN THE MUSSEL *MYTILUS EDULIS PLANULATUS* LAMARCK

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Text figs. 1-21.

SUMMARY

Mussels taken from Sydney Harbour between June 3 and August 18, 1960, spawned readily in the laboratory. Year-old females of shell length 40-59 mm. discharged an average of 1.85 million eggs. During early development the first micromere divided into two before the third micromere separated from the macromere. Records indicate the settling season in Sydney Harbour ranges from June to December with peaks about October and November. The mean length of year-old mussels taken from a raft in Sydney Harbour was substantially higher than that recorded for *Mytilus edulis edulis* Linné of comparable age.

INTRODUCTION

The biology of *Mytilus edulis planulatus* Lamarck in Sydney Harbour is not well known. Allen (1955) drew attention to the similarity in breeding temperature between this subspecies and *Mytilus edulis edulis* Linné. Wisely (1959) gave indications of the settling season of *planulatus* and more recently (1963) showed that the crawling larvae can detect an antifouling paint and show avoiding reactions to it. In the course of these investigations data have been collected on several other aspects of the biology of this organism which have not been reported on previously.

SPAWNING PERIOD

Observations made at the R.A.N. Station, Garden Island, in 1960, indicated that *planulatus* was in spawning condition suitable for artificial fertilization between June 3 and August 18. Gonad development increased during autumn (March-May) and by the beginning of winter (June) spawning seemed imminent. Accordingly, between June 3 and August 18, fourteen samples were taken from two rafts moored adjacently in the area. Each sample consisted of several hundred mussels of shell length 40-85 mm.; these were taken from just below (5 cm.) the waterline at the start of this sampling period, to deeper (30 cm.) at the end. These samples were transported in an insulated box without seawater to the laboratory and then immersed in a long shallow tank (2.3 x 0.2 x 0.7 m.) through which seawater flowed at a rate of about 360 l./hr.

Only two of these samples began spawning when placed in this tank, the July 13 sample began immediately and the August 3 sample commenced some four hours later. The rapidity of the July 13 spawning may have been associated with exceptionally heavy rainfall during the previous day. In the 24 hours preceding 9 a.m., July 13, 4.32 in. of rain fell in the general vicinity of Garden Island; this was practically equal to the average total rainfall for the month of July (4.45 in.). The resulting runoff discoloured surface water around Garden Island for several days and may have subjected the sample, which was taken only 5 cm. below the surface, to low salinities. The gonads of samples taken at the same depth seven days later were found to be spent. No unusual weather conditions were noted, however, during the few days preceding the taking of the August 3 sample. Samples taken from the same depth (30 cm.) on August 21, 26 and 29 were found to be spent and it was concluded that the spawning season had finished.

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The remaining 12 mussel samples collected between June 3 and August 18 did not spawn when they were placed in the running seawater tank; even though they were left there for several days, or in a few cases for a week. Spawning was induced in all these samples, however, by removing them in lots of about 50 and placing them in small tanks (0.3 x 0.3 x 0.5 m.) containing approximately 6 l. of stationary seawater. Usually several males commenced spawning within 30 minutes and this was followed by mass spawning of both sexes. The sperm and eggs obtained in all these samples were viable and young trochophores were subsequently obtained.

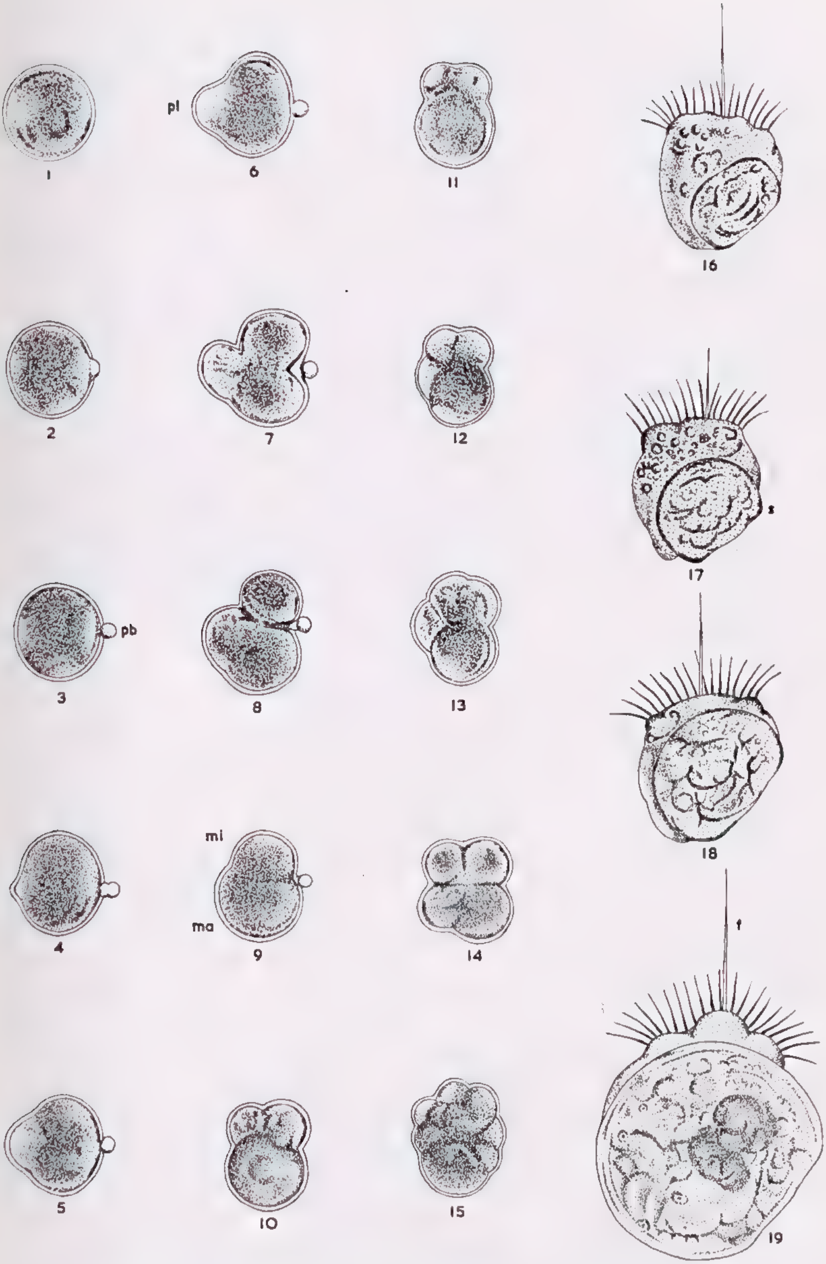
EGG NUMBERS

Females commencing spawning were removed immediately and placed singly in jars containing 1.5 l. of water. The latter was changed frequently to reduce the loss of eggs in suspension caused by their being sucked into the inhalent siphon and discharged as pseudofaeces. When spawning finished the mussels were opened and those not fully spent (8%) discarded. The shell lengths of the remainder were measured and the numbers of eggs released by them estimated. This was done by shaking the egg suspension until it appeared homogenous, withdrawing a 0.01 ml. sample and counting the eggs present in it. This procedure was repeated five times and the results averaged. The results obtained for 34 mussels of shell length 40-90 mm. are given in Table 1. The 27 mussels in the 40-59 mm. shell length range averaged 1.85 million eggs (range 0.96-5.08). These were taken from a raft which had been immersed only a year, indicating that the mussels had grown to maturity in that period. The eight mussels in the 60-90 mm. shell length range averaged 5.49 million eggs (2.35-10.00) but these mussels were taken from a raft immersed for several years.

EARLY DEVELOPMENT

The sperm head consists of an acrosome 2.5 μ long which is distinct from the large posterior part containing the nuclear material; the latter is globular with a truncate posterior end and measures 2 μ in length. The tail piece measures 42-46 μ in length. Before fertilization the egg is usually rounded or pear shaped with an irregular outline; after fertilization it becomes spherical and measures 63-66 μ in diameter (fig. 1). At 21°C. the first polar body appeared in most eggs 18-21 min. after sperm had been added (figs. 2, 3) and the second polar body about 20 min. later. No prominent external changes took place during the next 20-30 min. Then the vitelline membrane began to wrinkle on the side of the egg opposite the polar bodies. During the next 10 min. this region of the egg became less granular and the cytoplasm bulged out to form a large polar lobe (figs. 4-6). Transitory surface constrictions appeared giving the impression that the egg was becoming 3-celled but these disappeared as the polar lobe regressed into the lower part of the egg to form a large macromere (figs. 7-9). As this happened cleavage occurred in the plane of the polar bodies and separated off a micromere.

In *Mytilus edulis edulis*, Field (1922) considered the next stage was the formation of two more micromeres; the first of these was given off from the macromere and the second arose from the division of the original micromere almost at the same time. Observations on *planulatus* were made by adding fresh sperm to 2-cell eggs; the sperm, in attempting to fertilize the eggs, kept them rolling by the propulsive action of their tails. Individual eggs which were revolving slowly around an axis passing through the micromere and macromere were selected and observed. Division of the original micromere into two to give the 3-cell stage (fig. 10) was often observed. Figures 11-14 show the sequence of events drawn



Figs. 1-19: Stages in the development of *Mytilus edulis planulatus*. f = flagellae, ma = macromere, mi = micromere, pb = polar body, pl = polar lobe, s = shell (traced from photographs).

from successive photographs of the same egg. Figure 11 shows the 3-cell egg viewed from the side opposite the polar bodies. In figs. 12 and 13 the third micromere is shown developing from the macromere, and in fig. 14 the 4-cell stage consisting of three micromeres and the slightly larger macromere has been reached. Three-cell stages were most numerous about 60 min. after fertilization and there was a further lag of 20-30 min. before 4-cell stages became common. Divisions following the 4-cell stage and resulting in early blastulae (fig. 15) about 4 hours after fertilization were similar to those described by Field (1922) for *Mytilus edulis edulis*. Late gastrulae (20-24 hours after fertilization) were spherical or slightly oval and measured 63-66 μ in diameter.

In the young trochophore the posterior end became tapered and the cilia over the surface measured 10-20 μ in length. The cilia at the anterior end were longer and several flagellae measuring 50-55 μ in length appeared apically. The latter beat synchronously giving the impression they were one. During the next 24 hours shell glands appeared postero-dorsally and began to secrete the shell. The shell was at first a thin, flat, circular shape but subsequently divided along a line corresponding to the adult hinge line to form right and left valves. At this stage the stomodaeum, stomach and proctodaeum were already present and flagellates and other particles c. 2 μ in diameter were being ingested. Field (1922) figured a concave indentation at each end of the hinge line in comparable stage *edulis* but this indentation was not observed in *planulatus*. In the latter the edges of the valves curved around convexly from the end of the hinge line and maintained this shape during the next 1-2 weeks. The stages shown in figs. 16-19 were obtained in the laboratory by feeding the larvae with cultures of the small green flagellate *Nannochloris atomus* Butcher.

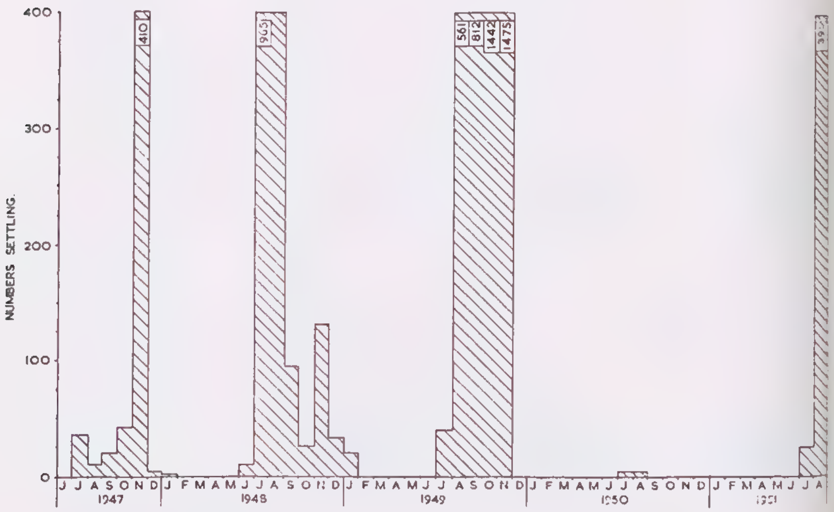


Fig. 20: Settling seasons of *Mytilus edulis planulatus* at the Spit Bridge, Sydney Harbour, 1947-51. Based on total counts of 4″ x 3″ ground glass plates immersed monthly. There was no count in August 1948 and the value for July was used.

SETTLING SEASONS

Settlement has been recorded on plates immersed at the Spit Bridge, North Head, Darling Harbour, Balmain and Garden Island (C.S.I.R.O., unpublished). These data substantiate Allen's (1955) suggestion that settlement commences in June or early July and terminates late in December. At the first three of these stations the average peak settlement months were October and November (Wisely, 1959). A series of monthly settling records obtained at the Spit Bridge between June, 1947, and August, 1951, is shown in fig. 20. In each year settlement commenced in June or July. The peak settling period varied from November (1947), July-August (1948) and October-November (1949). In June, 1950, abnormally heavy rainfall occurred at the Spit Bridge and may have been responsible for the abrupt termination of settling (Wisely, 1959).

GROWTH IN THE FIRST YEAR

One of the two rafts sampled at Garden Island was first immersed on June 30, 1959, and moored so that it was not in direct contact with wharves or the sea bed. The mussel population appearing on it during the following year most likely resulted from larval colonization. Two large samples of mussels were taken from the first raft on July 26, 1960; approximately one year after it had been immersed. The first sample of 664 was taken at a depth of 0-30 cm.; the shell length of these ranged from 12-59 mm. with a peak concentration at 35 mm. (fig. 21). The second sample of 340 was taken at a greater depth (46-122 cm.) and ranged from 24-66 mm. shell length with a peak at 49 mm. The mussels in the upper sample were clearly smaller and showed greater variability in length than those in the lower sample. The upper sample had a mean length of 35.3 ± 8.8 mm. (standard deviation) and the lower 48.9 ± 6.9 mm.

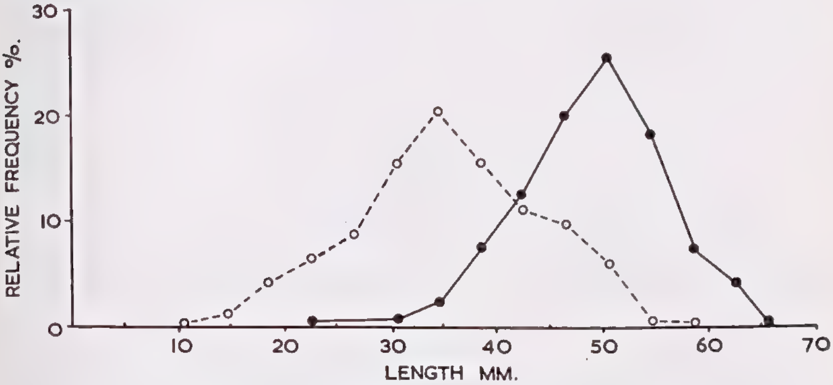


Fig. 21: Length frequency distributions of *Mytilus edulis planulatus* taken from a raft at the R.A.N. Station, Garden Island, after a year's immersion. The upper sample (-----) was taken from a depth of 0-30 cm.; the lower sample (———) from 46-122 cm. (4 mm. classes).

There are several points of interest in these samples. Firstly, it was shown earlier that mussels from 40-59 mm. shell length were capable of producing an average of 1.85 million eggs. Evidently about a quarter of the upper sample and most of the lower sample were capable of attaining this in their first year's growth (fig. 21). Secondly, growth was more rapid in the lower sample. Thirdly, the mean growth of both samples was in excess of Field's (1922) estimate for *Mytilus edulis edulis*. In summing up data from various sources Field considered that *edulis* could increase in length about 25 mm. annually for the first two or three years, providing it was in ideal conditions. Under the conditions found in many natural mussel beds however, growth was less and amounted to a total of about 76 mm. in 5-7 years. The means of both the Garden Island samples (35 and 49 mm.) were significantly higher than the 25 mm. annual increment for *edulis* under "ideal" conditions. However, it is pointed out that the Garden Island samples were from rafts, where the growing conditions were possibly more favourable than the sea beds where *edulis* normally occurs.

ACKNOWLEDGMENTS

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REFERENCES

ALLEN, F. E., 1955. Identity of breeding temperatures in Southern and Northern Hemisphere species of *Mytilus* (Lamellibranchia). *Pacif. Sci.* 9: 107-109.

FIELD, I. A., 1922. Biology and economic value of the sea mussel *Mytilus edulis*. *Bull. U.S. Bur. Fish.* 38.

WISELY, B., 1959. Factors influencing the settlement of the principal marine fouling organisms in Sydney Harbour. *Aust. J. Mar. Freshw. Res.* 10: 30-44.

WISELY, B., 1963. Detection and avoidance of a cuprous oxide antifouling paint by bivalve and gastropod larvae (Mollusca). *Aust. J. Mar. Freshw. Res.* 14: 60-69.

TABLE 1

NUMBER OF EGGS SPAWNED BY *MYTILUS EDULIS PLANULATUS* UNDER LABORATORY CONDITIONS

Mussel No.	Mussel Length (mm.)	Millions of Eggs	Mussel No.	Mussel Length (mm.)	Millions of Eggs	Mussel No.	Mussel Length (mm.)	Millions of Eggs
1	40	0.96	13	48	1.24	25	55	2.15
2	41	2.37	14	48	0.97	26	59	1.72
3	43	2.53	15	49	5.08	27	60	3.52
4	44	1.00	16	50	2.41	28	61	3.40
5	44	1.27	17	50	1.52	29	62	2.30
6	45	1.07	18	50	2.64	30	64	5.04
7	45	1.53	19	50	1.44	31	79	6.50
8	46	1.38	20	51	1.38	32	84	7.53
9	46	2.90	21	51	2.10	33	85	10.00
10	46	2.70	22	52	1.28	34	90	5.68
11	47	1.20	23	53	1.22			
12	47	1.86	24	54	2.31			